This is an excerpt from Frank Elavsky's dissertation on *Tool-making as an Intervention on the Accessibility of Interactive Data Experiences*, which can be accessed in full at this archival link:

http://reports-archive.adm.cs.cmu.edu/anon/hcii/CMU-HCII-26-103.pdf

This document contains the following sections:

- Chapter 1: Introduction
- Chapter 9: Discussion & Future Work (Sections 9.1 and 9.3 only)
- References

This document does not contain the following chapters:

- Chapter 2: Background & Related Work
- Chapter 3: Overview of Contributions
- Chapter 4: *Chartability*: Heuristics as a Tool and Resource
- Chapter 5: *Data Navigator*: Low-level Tooling for Creating Navigable Data Structures
- Chapter 6: *Skeleton*: Visual Authoring of Non-visual Data Experiences
- Chapter 7: *Cross-perception*: Rethinking Input Design Towards Blind Analytical Interaction
- Chapter 8: *Softerware*: Enabling Personalization of Interactive Data Representations for Users with Disabilities
- Chapter 10: Biographical Sketch

Part I

Introduction

Chapter 1
Introduction

This thesis is a body of research situated within the existing research area focused on making interactive data representations more accessible for people with disabilities. Much of the work in this existing area is situated within the context of making interactive data *visualizations* accessible, particularly (but not exclusively) for people who are blind. My work, contributed here in this thesis, is focused on using *tools* as a specific intervention and sub-area of study for making interactive data *representations* accessible for people with disabilities, broadly speaking. ("Representations" here is an intentionally broader term than "visualizations," which are exclusively visual representations of data.)

Before we begin, two things must be understood up front, or else the rest of this thesis could be interpreted with disruptive assumptions: we must interrogate the phrase "making visualizations accessible" and unpack why *tools* are a meaningful area of study.

1.1 Is "accessible visualization" really an oxymoron?

The first assumption that must be disrupted is perhaps the motivating cornerstone of this research, which is that the phrase "making visualizations accessible," while a noble goal, is not the semantically correct phrasing nor precisely what describes my work. This can be misleading. I do use the phrase "accessible visualization" but will admit that this seems to confuse certain people with very particular opinions about things. We will clear this up.

Villains of our field's past have written incendiary and ableist perspectives on why "no forms of data visualization, not just dashboards jam-packed with graphics, can be made fully accessible to someone who is blind," and that "[a blind man] will never be able to analyze data as I do visually, because many aspects of vision cannot be duplicated by his other senses" [6]. However, this position misunderstands what the goal of accessibility is, and arguably even what the goal of visualization itself is.

Making visualizations accessible *isn't* about the visualization, it's about making the outcomes of the visualization accessible.

Visualizations are ubiquitous and paramount for decision-making. However, the *artifact* that is a visualization is not even the goal of the act of visualizing: developing understanding, insight, confidence, and communication among and between human beings are the goals of visualization. Visualization is about making data easier to use for all kinds of things. Yes, our visual system enables us more than any other form of sensory cognition that we have [3, 8, 28]. But we aren't trying to make sight itself accessible. We are trying to make it possible for people to make meaningful decisions, gain valuable information, build conjectures, and effectively communicate with others.

Many, many people who I've spoken to over the course of my career, even before embarking on this thesis journey, misunderstand this simple fact: making a "visualization" accessible *isn't* about the visualization itself but rather making what the visualization is meant to *accomplish* accessible. It's about equal outcomes, not equal interactions with an artifact.

People with disabilities are no small portion of the world's population. In the United States, 27% of people self-report living with at least one disability that affects their daily lives [20] and all of us will eventually age into disability (if we are lucky to live a long life).

People with disabilities (again, that will be all of us *eventually*) deserve to participate fully in life. They deserve financial independence. They also deserve loving care and interdependence. People with disabilities have a right to make informed decisions, to know about the status of a global pandemic, and to have an understanding of local and national politics [5]. While we use visualizations to navigate all of these domains, the goal is not to make the charts and graphs themselves somehow equally useful to all people. That would be a false measurement of success.

Our goal then, is measured by the success of lives led by people with disabilities [29]. Many other measurements are just metrics along the journey towards that goal. We then ask: Can people with disabilities also use data to live full lives? Can they make *fast* decisions based on data? Meaningful, careful, *slow* decisions? Communicate complex ideas? Crunch and clean data, develop models, find errors, and build hypotheses? Can they have memorable, immersive, beautiful, aesthetic experiences with data too [14]? Making "visualizations" accessible really is a misnomer. We are ultimately trying to make everything about what interactive data experiences *accomplish* for people equitable and accessible.

Again, if the goal of accessible visualization were about visualizations themselves, then the correct course of action would be one framed by the medical model [18]: that there is a normative state of behavior and capability (in this case, it would be "normal" to be able to read a visualization and make a decision) and any deviation from that norm must be corrected. This framing first assumes that the visualization should not be altered or improved. And then this framing puts the burden on the bodies of people with disabilities: that they must be "fixed" and given sight or brought to some equivalent state as someone who is "healthy," normal, and sighted. Plenty of scholars have already discussed why this framing is a problem, not only because it places undue burden on people with disabilities, produces pathologies and hierarchies of disability, but also because it is fundamentally not economically or ethically feasible.

So we then turn to other models of disability, such as the social model. The social model is heavily discussed by disability scholars and is not the end-game or last and total way of thinking about disability [18, 21, 22, 27, 36]. But the core motivation is that society, not medicine, is also a path towards solving problems that people with disabilities face. A few important concepts and concretely actionable things come from the social model that can help motivate the work of this thesis.

First, we look to the historical birth of the social model of disability: in the 504 sit-ins that took place in the United States in 1977. Cities had curbs and curbs are a barrier for people who use wheelchairs. So protests happened because decisions were being made without people with disabilities at the table. In this instance, people acknowledged that political power was an exclusive club and fought to ensure their cry "nothing about us, without us!" materialized.

And this leads us to the first and most-foundational philosophical framing for this thesis: that our *artifacts*, these things we've created from curbs to data visualizations, can become *barriers* for people with disabilities. And it is then the artifact, not the body of the person with a disability, where disability is produced in this model. Rather than a comparison to a normative state as a way to frame disability (the medical model), we instead must observe and evaluate material outcomes based on human-made problems.

So, the social model is framed around society "solving" inequities: we get involved and make political and legal change tangible. But a second model also emerges from within the social model: one where we can now frame *who is first responsible* for repair: the curb designers and implementers.

And knowing who is first responsible for access leads us into the moral and ethical imperative that motivates this thesis: the builders and makers of visualizations are ultimately the ones who provide exclusive value for only a subset of people: those *without* disabilities. **We must first change how builders and makers do their work.**

So the phrase "accessible visualization" is really about recognizing that visualizations produce barriers for people. That means that it is our ethical imperative, as builders and makers, to fix them. And that act of fixing barriers leads us away from mere visual representations of data into a wide variety of other senses and interaction modalities. There are many paths forward towards fuller and more-equitable lives led by people with disabilities.

1.2 On *tools*, *tool-making*, and *human-tool* interaction

Then the act of making becomes immensely important: we, the builders and makers of our world, need to get things right; there is a risk involved when making things that we will exclude people with disabilities. We need to make sure that we build a better world than the one we have now. We must care for new things we create and tend to the repair and maintenance of what we've already made. And this ethical imperative leads us to the topic of *tools* and *tool-making*.

So the second thing that must be understood before we embark on this thesis is that *tools* are not the same as *solutions* or *applications*. Sometimes tools can be used to *solve* things and are certainly, in ideal circumstances, *applied* in various contexts. But understanding the role of the "tool" in human-tool interaction is paramount for engaging in the work of making anything accessible for people with disabilities.

We use tools to shape our world, break old things, and make new things. But a tool, like the hammer (as an example), does not inherently *solve* something like homelessness. But a hammer can be used to build homes if there are social policies in place and proper resources allocated. This means that for the success of tooling, there is often a larger material, social, legal, and policy reality that supports and necessitates those tools. This thesis will not be focusing on changing the upstream dependencies, but optimistically operating as if they were true (or will be true in time).

However, in some cases, tools can *destroy*. The hammer has a claw and can easily pry apart boards and tear down homes. So tools carry potential to do all kinds of things, both good and bad, and how a tool is used is often open-ended, variable, and heavily dependent on socio-technical realities. Tools participate in personal and political agendas [33] and are sometimes, for this reason, regulated or made proprietary and controlled by powerful entities [10, 32].

So tools are not without any sort of ethics. We cannot just blame tool-users for outcomes when much of a tool depends on these larger systems and structures. Technologies (tools included) encode the assumptions and biases of their *creators* as much as, if not more than, their users. Tools that build things for others to use can be loaded with assumptions about what people are *able* to do [34] and also rules and guardrails about what anyone downstream from that tool's design *should* do [10, 31]. These assumptions, biases, and rules *limit*, *enforce*, *magnify*, *exclude*, and *enable* what a tool-user is capable of.

Tools for visualizing data are a perfect case study in this problem: virtually every major data visualization library, application, or software ever made was made entirely with the assumption that data should be transformed into visual representations. This is a reasonable assumption, since virtually all of the tool-makers are sighted and visualization is incredibly helpful to our cognition of and communication with data [7].

So data visualization, as a field, has focused its tool-making efforts on reducing the difficulty involved in visualizing data. Some visualization tools are concise [25], others are lower level but much more expressive [2]. Tool-making in visualization has focused on making it easier to scaffold a wide variety of interactions both with the visualizations as well as with their underlying data models [12].

However, as time has moved on, people began to speak out about color-vision deficiency in data visualization. Some people, primarily those with X/Y chromosomes (largely men) who are of European ancestry, have a deficiency in their ability to perceive certain colors. Then a plethora of research arose that began to look into the barriers that folks who are colorblind face in data visualization. As a result, our practices and tools improved. We began to educate practitioners, develop new color palettes, researched new methods for testing our designs, and built new systems for handling automatic color encoding. Our tools evolved.

But now data visualizations have arguably become ubiquitous in daily life. By comparison, we have far more tools now for making visualizations quickly and easily than we do for representing data in non-visual ways. We also have far more research, relatively speaking, into how sighted end users interact with visualizations.

So this thesis engages gaps that arise in this space: Practitioners face immense challenges when crafting accessible data experiences. We first need to educate practitioners on what accessibility barriers actually are in interactive visualizations. Then, we must help them engage the hardest barriers in this work and create building blocks that help them to construct navigable data experiences, build design frameworks that can inform entirely new kinds of data interaction, and develop software systems for end-user personalization and agency. Our research seeks to advance the state of the art in tools that assist in accessible data interaction while also using tool-making as an intervention that helps us to better understand and characterize *why* and *how* data practitioners face barriers themselves in this work.

Part VI

Conclusion

Chapter 9
Discussion & Future Work

9.1 What is a "tool?" A reflection on the social and material identity of tools

In the introduction of this dissertation, I use the example of a hammer: a hammer can destroy and it can construct. So is the *use* of a technology what constitutes it? Do we understand the hammer as the *thing we swing, to destroy and to build*? Should we?

This thesis engages domains of tools and tool-making for accessibility: evaluation, navigation, interaction, and personalization. But these categories for work do not fully characterize the upstream conditions that our software systems and data interfaces inherit.

In my work specifically on accessibility, a larger social reality becomes apparent that shapes the question, "what is a tool?" far more than how an individual might use one, or the domains of work that our tool-making inhabits. My research journey has navigated multiple social and political thresholds, from changes to law in the European Union, to the enactment of Title II as part of the update to the Americans with Disabilities Act. These laws have motivated a significant interest in accessibility research, solutions, guidelines, and technologies. In the midst of this, we have seen the rise of overlays and generative AI solutionism [11] and subsequent lawsuits and grass-roots resistance.

For my work, this is mostly good news. Legal change produces motivation, and even with predatory technology attempting to address real problems, pushback is widespread and active. But this paints a picture of the reality that my work inherits: many tools cannot even be used, or cease to be used, if there is not a social, political, and material set of conditions in place motivating those tools, providing resources for their construction, regulating their use, and examining the outcomes of what they accomplish. Tools and technologies are often a response to social, cultural, political, and legal realities that we first negotiate.

I recently spoke on this at a keynote in Australia, on how a hammer isn't *just* a tool and that the idea that "the only thing that matters is how a tool is used" limits how we really understand tools. Instead, I spoke about how a standard, household hammer requires iron and wood. That alone leads to a whole universe of different questions. Western Australia's conservation efforts were disrupted when a significant amount of natural iron was discovered in a wildlife preserve. So laws were passed and now iron is mined there. That iron is largely exported. And Australia then, whether with Australian iron or not, mostly imports their small tools. Iron is sent out, and through a complex network of trade (likely indirectly related to the iron), hammers are brought in. A "hammer," to even exist at all, relies on multiple levels of human governance, international relations, and complex infrastructures of trade.

And while my metaphor is largely motivated to encourage younger practitioners to consider the "iron mines" in the technologies they use, such as modern generative AI, it is also an area that is not adequately explored and addressed in terms of accessibility research.

Research on accessibility is dependent on funding, which is often dependent on political priorities and action. Depending on the current social and political state of the world at large, accessibility research itself may never gain the opportunities required in order to innovate and produce new tools at all. And as the US's 2025 federal cuts to research demonstrated, millions of dollars devoted to accessibility research can be lost to political agendas. It is for this reason that engagement with policy recommendation and guidance is essential. Personal political activity and involvement is also essential. Researchers who genuinely believe in accessibility as a human right or as a dignity that all people deserve should work with policymakers to ensure that there are material and structural resources in place for this work to continue. We cannot naively believe that technology, divorced from the realm of social and political forces, is capable of solving accessibility barriers [27]. Without enforcement and threat of litigation, very little accessibility work has been accomplished in the past by technology companies alone.

Not featured in these chapters (as they were merely stapled in research papers from previous publications) is the policy and outreach work involved in seeing that work like *Chartability* and *Data Navigator* are used in real contexts, including by organizations that govern and influence the lives of many people. Immediate incentives to produce novelty may not be enough to sustain the larger socio-cultural and political ecosystems that our work participates in and is downstream from. We must also get involved.

9.3 Who is responsible for repair?

Lastly, I want to revisit one of my opening points, where I argue that the *tool-makers* are first responsible for repair. This is true. However, the most pressing issue I have faced in recent years is mostly unmentioned across these research projects: tool-makers might be responsible, but this is because they are the only ones who have the *power* to make things accessible. Does this always need to be the case? Can we imagine an artifact's authority over the user's ability to access being designed towards self-subversion [9] or de-centralized agency [4, 16, 19], instead? What might that look like, concretely?

In *Softerware*, we begin to engage this larger problem in terms of an idealized state where a user can repair or re-design their own experiences. But to me, this self-repair is like laying down train tracks for yourself as you move a locomotive, but then lifting up your own tracks behind you as you go. You're the only one helping yourself. This is not ideal, for you or others.

What we need are broad, lasting, infrastructural changes. On the web, this problem becomes quite difficult to solve. A personal computer or device? Again, someone can auto-design their interfaces into a better state. But back when I started *Chartability*, the WebAim Million's report showed more than 95% of the top one million website home pages contain at least one critical accessibility error. And now, more than 6 years later, that proportion is unchanged [30].

Some had imagined that generative AI would solve the massive infrastructural repair problems we face. But unfortunately, the latest WebAim Million report shows that since 2020, ARIA usage has increased and correlates to more errors, while use of tabindex on a page has increased nearly 300% and also correlates to more errors on a page. If anything, during the age of generative AI, we have seen existing bad patterns worsen in prevalence and complexity.

I firmly believe that a tools-based approach is not enough on its own. Tool-making cannot be the *only* intervention on inaccessibility. Tools and tool-making, as our thesis argues, have a powerful role to play. But we simply can't tool our way out of failed infrastructure and inadequate policy when someone else *owns* the tools and tool-making. Visiting a website is like going into someone else's home: arranged according to their effort, tastes, and so on. If you can't access their home, you essentially need to request that they let you in personally. Website repair always falls to the owner and maintainer of a website, and they largely don't take any meaningful action.

Sidewalks outside of homes are a good parallel to this problem. Sidewalk accessibility is a massive infrastructural problem [24], and yet localities treat sidewalk maintenance in different ways: some, like where I presently live in the south hills of Pittsburgh, put the onus on the homeowner whose house and property the sidewalk touches. In other places, sidewalks are considered a public path, similar to a roadway, and are maintained through public tax and resource management. To no surprise, privately-maintained, public-access sidewalks are worse for people in pretty much every way than publicly-maintained ones [35]. This is because private homeowners don't care about sidewalk maintenance unless the city manages to fine them or they get sued.

And the web is a collection of private spaces that you visit privately. There is no truly shared, universally democratic, public space on the web. Centralization is partly to blame: sharing space while scaling leads to consolidation.

So my future work will continue to wrestle with the same tensions of scale, repair, and anti-consolidation of power, motivated by the same WebAim Million report. But now I look to questions of *democratic* and *radical* access to accessibility repair. The barriers I hope to tackle in the future are political and infrastructural. Perhaps tool-making will participate in this work, but it seems clear now from my work that the upstream technical problems and socio-political conditions that tools inherit, will likely not be addressed by tools alone.

What does "democratic" and "radical" infrastructure work look like? It will probably be an extension of *Softerware*, to some degree. I imagine future research that explores public-first spaces, ones where access is socially negotiated and repair belongs to all of us. Is this an autonomous space, like an autonomous zone [1] separate from the web? Above it, looking down into it, like shared annotation tools but capable of sharing the manipulation of websites [23]? A space with ambient co-repair, modeled after projects that bring people together [26] or that allow community "fixing" of misinformation [15]? Perhaps feminist thought on the ethics of care can help us [13, 17]? Or maybe it will be something else entirely; I'm not yet sure. But what made the web fantastic years ago is long gone; most of it has been hedged into corporate spaces that are controlled, maintained, and repaired by corporate power. And these entities are notoriously bad at repair. What I imagine in the future involves reclaiming a sense that the web is *ours*, belongs to *us*, and that ultimately *we* are responsible for making it accessible.

References

[1] Hakim Bey. *TAZ: The temporary autonomous zone, ontological anarchy, poetic terrorism*. Autonomedia, 2003. 9.3

[2] M. Bostock, V. Ogievetsky, and J. Heer. D³ data-driven documents. *IEEE Transactions on Visualization and Computer Graphics*, 17(12):2301–2309, December 2011. ISSN 1077-2626. doi: 10.1109/tvcg.2011.185. URL `https://doi.org/10.1109/tvcg.2011.185`. 1.2

[3] Jennifer L. Burke, Matthew S. Prewett, Ashley A. Gray, Liuquin Yang, Frederick R. B. Stilson, Michael D. Coovert, Linda R. Elliot, and Elizabeth Redden. Comparing the effects of visual-auditory and visual-tactile feedback on user performance. In *Proceedings of the 8th international conference on Multimodal interfaces*, ICMI06, pages 108–117. ACM, November 2006. doi: 10.1145/1180995.1181017. URL `https://doi.org/10.1145/1180995.1181017`. 1.1

[4] Katherine Casey. Radical decentralization: Does community-driven development work? *Annual Review of Economics*, 10(1):139–163, August 2018. ISSN 1941-1391. doi: 10.1146/annurev-economics-080217-053339. URL `http://dx.doi.org/10.1146/annurev-economics-080217-053339`. 9.3

[5] Danyang Fan, Alexa Fay Siu, Hrishikesh Rao, Gene Sung-Ho Kim, Xavier Vazquez, Lucy Greco, Sile O'Modhrain, and Sean Follmer. The accessibility of data visualizations on the web for screen reader users: Practices and experiences during covid-19. *ACM Transactions on Accessible Computing*, 16(1):1–29, March 2023. doi: 10.1145/3557899. URL `https://doi.org/10.1145/3557899`. 1.1

[6] Stephen Few. Visual Business Intelligence - Data Visualization and the Blind. `https://www.perceptualedge.com/blog/?p=1756`, 2013. [Accessed 05-04-2025]. 1.1

[7] Steven L. Franconeri, Lace M. Padilla, Priti Shah, Jeffrey M. Zacks, and Jessica Hullman. The science of visual data communication: What works. *Psychological Science in the Public Interest*, 22(3):110–161, December 2021. ISSN 1539-6053. doi: 10.1177/15291006211051956. URL `https://doi.org/10.1177/15291006211051956`. 1.2

[8] Michele E. Gloede and Melissa K. Gregg. The fidelity of visual and auditory memory. *Psychonomic Bulletin & Review*, 26(4):1325–1332, August 2019. ISSN 1531-5320. doi: 10.3758/s13423-019-01597-7. URL `https://doi.org/10.3758/s13423-019-01597-7`. 1.1

[9] David Graeber and Charlie Rose. Never cower to authority, 2006. URL https://www.youtube.com/watch?v=qt5op6wft-8. Accessed [2026]. 9.3

[10] David Gray Widder, Sarah West, and Meredith Whittaker. Open (for business): Big tech, concentrated power, and the political economy of open ai. *SSRN Electronic Journal*, 2023. ISSN 1556-5068. doi: 10.2139/ssrn.4543807. URL https://doi.org/10.2139/ssrn.4543807. 1.2

[11] Parker Hartman and Tim Gorichanaz. Evaluating ai-powered website accessibility overlays. In *Proceedings of the 27th International ACM SIGACCESS Conference on Computers and Accessibility*, ASSETS '25, page 1–4. ACM, October 2025. doi: 10.1145/3663547.3759761. URL http://dx.doi.org/10.1145/3663547.3759761. 9.1

[12] Jeffrey Heer and Dominik Moritz. Mosaic: An architecture for scalable & interoperable data views. *IEEE Transactions on Visualization and Computer Graphics*, pages 1–11, 2023. ISSN 1077-2626, 1941-0506, 2160-9306. doi: 10.1109/tvcg.2023.3327189. URL https://doi.org/10.1109/tvcg.2023.3327189. 1.2

[13] Ana O Henriques, Anna R. L. Carter, Beatriz Severes, Reem Talhouk, Angelika Strohmayer, Ana Cristina Pires, Colin M. Gray, Kyle Montague, and Hugo Nicolau. A feminist care ethics toolkit for community-based design: Bridging theory and practice. In *Proceedings of the 2025 CHI Conference on Human Factors in Computing Systems*, CHI '25, page 1–26. ACM, April 2025. doi: 10.1145/3706598.3713950. URL http://dx.doi.org/10.1145/3706598.3713950. 9.3

[14] Stacy Hsueh, Beatrice Vincenzi, Akshata Murdeshwar, and Marianela Ciolfi Felice. Cripping data visualizations: Crip technoscience as a critical lens for designing digital access. In *The 25th International ACM SIGACCESS Conference on Computers and Accessibility*, ASSETS '23, page 1–16. ACM, October 2023. doi: 10.1145/3597638.3608427. URL http://dx.doi.org/10.1145/3597638.3608427. 1.1

[15] Farnaz Jahanbakhsh, Amy X. Zhang, Karrie Karahalios, and David R. Karger. Our browser extension lets readers change the headlines on news articles, and you won't believe what they did! *Proceedings of the ACM on Human-Computer Interaction*, 6(CSCW2):1–33, November 2022. ISSN 2573-0142. doi: 10.1145/3555643. URL http://dx.doi.org/10.1145/3555643. 9.3

[16] Os Keyes, Josephine Hoy, and Margaret Drouhard. Human-computer insurrection: Notes on an anarchist hci. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, page 1–13. ACM, May 2019. doi: 10.1145/3290605.3300569. URL http://dx.doi.org/10.1145/3290605.3300569. 9.3

[17] Els Maeckelberghe. Feminist ethic of care: A third alternative approach. *Health Care Analysis*, 12(4):317–327, December 2004. ISSN 1573-3394. doi: 10.1007/s10728-004-6639-6. URL http://dx.doi.org/10.1007/s10728-004-6639-6. 9.3

[18] Deborah Marks. Models of disability. *Disability and Rehabilitation*, 19(3):85–91, January 1997. ISSN 1464-5165. doi: 10.3109/09638289709166831. URL https://doi.org/10.3109/09638289709166831. 1.1

[19] Giles Mohan and Kristian Stokke. Participatory development and empowerment: The

dangers of localism. *Third World Quarterly*, 21(2):247–268, April 2000. ISSN 1360-2241. doi: 10.1080/01436590050004346. URL http://dx.doi.org/10.1080/01436590050004346. 9.3

[20] CA Okoro, ND Hollis, AC Cyrus, and S. Griffin-Blake. Prevalence of disabilities and health care access by disability status and type among adults — united states, 2016. *Centers for Disease Control and Prevention MMWR*, 67:882–887, 2018. doi: 10.15585/mmwr.mm6732a3. 1.1

[21] Blake Ellis Reid. The curb-cut effect and the perils of accessibility without disability. *SSRN Electronic Journal*, 2022. doi: 10.2139/ssrn.4262991. URL https://doi.org/10.2139/ssrn.4262991. 1.1

[22] Rod D Roscoe, Erin K Chiou, and Abigail R Wooldridge, editors. *Advancing diversity, inclusion, and social justice through human systems engineering*. CRC Press, London, England, December 2019. 1.1

[23] Heather Ruland Staines. Digital open annotation with hypothesis: Supplying the missing capability of the web. *Journal of Scholarly Publishing*, 49(3):345–365, April 2018. ISSN 1710-1166. doi: 10.3138/jsp.49.3.04. URL http://dx.doi.org/10.3138/jsp.49.3.04. 9.3

[24] Manaswi Saha, Michael Saugstad, Hanuma Teja Maddali, Aileen Zeng, Ryan Holland, Steven Bower, Aditya Dash, Sage Chen, Anthony Li, Kotaro Hara, and Jon Froehlich. Project sidewalk: A web-based crowdsourcing tool for collecting sidewalk accessibility data at scale. In *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems*, CHI '19, page 1–14. ACM, May 2019. doi: 10.1145/3290605.3300292. URL http://dx.doi.org/10.1145/3290605.3300292. 9.3

[25] Arvind Satyanarayan, Dominik Moritz, Kanit Wongsuphasawat, and Jeffrey Heer. Vega-lite: A grammar of interactive graphics. *IEEE Transactions on Visualization and Computer Graphics*, 23(1):341–350, January 2017. doi: 10.1109/tvcg.2016.2599030. URL https://doi.org/10.1109/tvcg.2016.2599030. 1.2

[26] Hanieh Shakeri, Ye Yuan, Benett Axtell, Denise Y. Geiskkovitch, and Carman Neustaedter. Designing smart home technology for passive co-presence over distance. In *Designing Interactive Systems Conference*, DIS '24, page 3389–3406. ACM, July 2024. doi: 10.1145/3643834.3661508. URL http://dx.doi.org/10.1145/3643834.3661508. 9.3

[27] Katta Spiel, Kathrin Gerling, Cynthia L. Bennett, Emeline Brulé, Rua M. Williams, Jennifer Rode, and Jennifer Mankoff. Nothing about us without us. In *Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems*, CHI '20, pages 1–8. ACM, April 2020. doi: 10.1145/3334480.3375150. URL https://doi.org/10.1145/3334480.3375150. 1.1, 9.1

[28] Sebastian Paul Suggate. Beyond self-report: Measuring visual, auditory, and tactile mental imagery using a mental comparison task. *Behavior Research Methods*, 56(8):8658–8676, September 2024. ISSN 1554-3528. doi: 10.3758/s13428-024-02496-z. URL https://doi.org/10.3758/s13428-024-02496-z. 1.1

[29] Yuanyang (YY) Teng and Darren Gergle. Access is not enough: Toward developmental flourishing. In *Proceedings of the Extended Abstracts of the 2026 CHI Conference on Human Factors in Computing Systems*, CHI EA '26, page 1–6. ACM, April 2026. doi: 10.1145/3772363.3798552. URL `http://dx.doi.org/10.1145/3772363.3798552`. 1.1

[30] WebAIM. Webaim: The WebAIM Million - An annual accessibility analysis of the top 1,000,000 home pages. https://webaim.org/projects/million/#wcag, 2021. Accessed: 2021-09-03. 9.3

[31] David Gray Widder and Richmond Wong. Thinking upstream: Ethics and policy opportunities in ai supply chains, 2023. URL `https://arxiv.org/abs/2303.07529`. 1.2

[32] David Gray Widder, Meredith Whittaker, and Sarah Myers West. Why 'open' ai systems are actually closed, and why this matters. *Nature*, 635(8040):827–833, November 2024. ISSN 1476-4687. doi: 10.1038/s41586-024-08141-1. URL `https://doi.org/10.1038/s41586-024-08141-1`. 1.2

[33] Langdon Winner. Do artifacts have politics? In *Computer Ethics*, pages 177–192. Routledge, May 2017. ISBN 9781315259697. doi: 10.4324/9781315259697-21. URL `https://doi.org/10.4324/9781315259697-21`. 1.2

[34] J. O. Wobbrock, S. K. Kane, K. Z. Gajos, S. Harada, and J. Froehlich. Ability-based design: Concept, principles and examples. *ACM Transactions on Accessible Computing*, 3(3):1–27, April 2011. doi: 10.1145/1952383.1952384. 1.2

[35] Mintesnot Woldeamanuel and Andrew Kent. Measuring walk access to transit in terms of sidewalk availability, quality, and connectivity. *Journal of Urban Planning and Development*, 142(2), June 2016. ISSN 1943-5444. doi: 10.1061/(asce)up.1943-5444.0000296. URL `http://dx.doi.org/10.1061/(ASCE)UP.1943-5444.0000296`. 9.3

[36] Rebecca Yeo and Karen Moore. Including disabled people in poverty reduction work: "nothing about us, without us". *World Development*, 31(3):571–590, March 2003. ISSN 0305-750X. doi: 10.1016/s0305-750x(02)00218-8. URL `https://doi.org/10.1016/s0305-750x(02)00218-8`. 1.1